The Emergency Management Synchronization Matrix — A Method of Coordinating, Integrating, and Synchronizing Disaster Response

Paul L. Hewett, Jr., Argonne National Laboratory, plhewett@anl.gov
Jacques E. Mitrani, Argonne National Laboratory, JacquesM@anl.gov
William C. Metz, Ph.D., Argonne National Laboratory, wmetz@anl.gov
9700 South Cass Avenue
Argonne, Illinois 60439

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Abstract

A graphical depiction of the entire response process via an innovative emergency response synchronization matrix is an effective tool for optimizing the planning, exercising, and implementation of emergency plans, procedures, and checklists. This systems-based approach to emergency planning illustrates how a community proposes to organize its response tasks across space and time in relation to hazard actions. It offers an opportunity to identify all inter-jurisdictional dependencies and resolve their relationships prior to an actual crisis. The community is also able to make real-time adjustments during response planning, as necessary, to maximize the often limited resources available for protecting area residents. An effective response to an accidental release of chemical warfare agent or any natural or technological hazard must involve the entire community and must not be discombobulated by individual jurisdictions and organizations acting on their own without the critical coordination, integration, and synchronization.

BACKGROUND

An emergency response to an accidental release of chemical warfare agents from one of our nation's eight chemical weapons stockpile sites, like any other disaster response, is complex. It requires the rapid coordination, integration, and synchronization of multiple governmental and non-governmental organizations from many levels and jurisdictions, each with varying response capabilities, into a unified community response. A community's response actions occur in an area extending from an on-site storage location to points 30 or more miles away. Actions are directed and controlled by responding local governments and agencies within the response area, as well as by state and federal operations centers and agencies far removed from the area of impact. Time is critical, and the protective action decision-making process is greatly compressed. To ensure an effective response with minimal confusion, given the potentially catastrophic nature of such releases, the response community must carefully synchronize all of their response plans, procedures, and checklists.

PROBLEM: DISCOMBOBULATED RESPONSES

Recent domestic counterterrorism drills being conducted across the country have verified what has been a common theme for decades in the natural and technological disaster response lessons-learned literature — the need for all levels of government to develop a cooperative plan for and response to emergencies. Currently, there is a very limited understanding of how all the moving parts of a response to an emergency would function in relation to response requirements and to one another. In an emergency response, the whole is not only greater, but it is also different than the sum of its parts [1].

Emergency planning by state and local government emergency management agencies typically results in multi-chapter, several volume emergency operations plans, standard operating procedures, and checklists. Generally, planning takes into account the potential needs of the general public, special facilities and individuals with special needs, and responders, as well as the resources and capabilities over which the agencies have direction and control. While emergency management agencies develop response plans, procedures, and checklists for the potential hazards within their jurisdictions based on their specific needs, situation, and resources, plan development seldom involves rigorous coordination or fully considers intra- and inter-jurisdictional relationships [2-4].

When faced with a fast-paced, terrifying disaster, as in the unlikely event of an accident at a chemical weapons stockpile site, well-developed predisaster planning and coordination of responder action at all levels and within and between affected jurisdictions are imperative. Response plans must convey the necessary activities and inter-jurisdictional relationships, predecessors, and dependencies in a readily apparent fashion to the large number of professional and volunteer responders. Dynes and Warheit [5] identified "more than sixty discrete units of government ranging from volunteer fire departments to the Executive

Office of the President" as having responded to a tornado in Topeka, Kansas. Drabek and colleagues [6] indicated that a response to even a "minor disaster" requires the involvement and interaction of 10 to 80 governmental and non-governmental organizations. Quarantelli [2] pointed out that these voluminous emergency plans often fail to take into account a community's perspective of the response process. Moreover, plans often do not reflect the way a jurisdiction actually responds because most are written to guidance, not a concept of operations.

Human factor studies show us that as the complexity of a situation and volume of information increase in relation to the human brain, the entire problem — in this case, the planned response to a disaster — can no longer be adequately managed in active memory. A person's cognitive, motor, and perceptual resources "are typically limited in the sense that each can normally be used for only one task at a time" [7]. While most governmental and non-governmental organization emergency response directors have an overall sense of their own response plan, procedures, and checklists, during a response, the actual implementing details can be overwhelming. Since many responders and staff are volunteers or occasional participants, it can be problematic to develop or refresh their understanding of plans, procedures, and checklists while actively engaged in implementing a response. Therefore, as the complexity of emergency response planning increases because of expanding inter-jurisdictional and organizational interactions, it becomes exceedingly more difficult for a person to understand and visualize the interplay of a complete set of response plans, procedures, and checklists and to manage within a synchronized community response.

SOLUTION: A SYSTEMS-BASED PROCESS

In developing a systems-based process solution by which emergency planners and responders can coordinate, integrate, and synchronize their emergency plans, procedures, and checklists, Argonne National Laboratory constructed a response management tool based on proven Army processes used to plan the complex operations at the heart of their Air-Land Battle concept. Linking functional operating systems with space, time, and expected enemy actions, the Army established a framework, the synchronization matrix, for solving the complex planning problem associated with this new concept. Similarly, Argonne's emergency response synchronization matrix (ERSM) was developed to organize the increasingly complex inter-jurisdictional response necessary to meet the Chemical Stockpile Emergency Preparedness Program (CSEPP) response requirements. Supported by a state-of-the-art software application, this interactive, system-based process helps planners develop coordinated, integrated, and synchronized response plans. When used in conjunction with skilled emergency preparedness experts, the emergency response activities of all involved response agencies (federal, tribal, state, county, municipality, and volunteer organizations) can execute a unified community response to any emergency situation and, with appropriate feedback, adjust their actions as the response takes place and evolves.

ERSM as a Planning, Evaluation, and Response Implementation Tool

The ERSM provides a graphical portrayal of the response activities to be taken by each of the jurisdictional authorities and responders in conjunction with a community response to a hazard or crisis. For planning, the ERSM can depict the general community response scheme. It can also show the detail of a jurisdiction's portion of that scheme, ensure that all plans are integrated and synchronized by resource loading and "war-gaming" response tasks as the ERSM is developed, provide plan reviews, and guide plan revision. For evaluation, the ERSM "picture" provides an exercise design tool to structure a robust simulated event, ensures that implementers are injected at the appropriate time, allows an evaluator to compare what occurred in the exercise to both a jurisdiction's and community's plan , and provides a graphical report when actual response actions are overlaid on planned actions. For response implementation, the ERSM permits responding jurisdictions to see how they fit into a community response as it progresses, identifies the effects of early or late actions, and facilitates mutual aid or outside responder understanding of and assimilation into the response.

Response Operating Systems

In adapting the Army's concept, Argonne first identified and finalized a set of functional operating systems used in emergency response. Response operating systems (ROS) are comprised of groupings of critical major functions performed by governmental and non-governmental organizations to successfully respond to disasters and protect the public. While other researchers [8-10] delineated 4, 8, and 14 ROS, Argonne refined the functional patterns into 6 ROS. This decision was based on two decades of experience in evaluating response plans and operations during exercises carried out under the Federal Emergency Management Agency's Radiological Emergency Preparedness Program and the Army's CSEP Program at facilities across the United States. The six ROS are: emergency management, hazard mitigation, emergency assessment, victim care, protection, and evacuee support. Each ROS is composed of a set of supporting task groups that are its “functions.” Activities are then placed within specific functions as they relate to the function.

Organizing Disaster Response Space

Disaster response space is that area where emergency managers conduct response operations. The affected space can expand and contract over time on the basis of the nature and threat of the hazard, resources being brought to bear, and number and variety of responding agencies. What occurs in each area is not separate and distinct; rather all actions are aimed at achieving the end state and thus must be coordinated, integrated, and synchronized to maximize the effectiveness and efficiency of the community response. Actions occur in all response areas simultaneously, so timing is key. Response space can be divided into three separate, though not necessarily continuous, spatial components: near, adjacent, and far. Figure 1 shows the response area organization for a chemical stockpile emergency at the Blue Grass Army Depot in Kentucky.

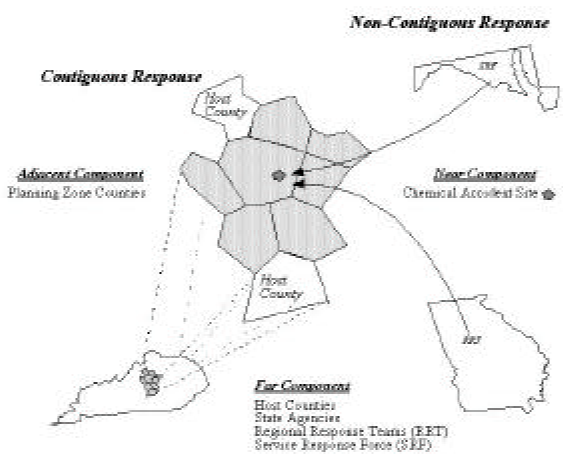

Figure 1. Response Area Organization for Kentucky

Constructing the Matrix

The ERSM produces a graphical portrayal of jurisdictional and community responses using the ROS, spatial representation, and arraying response activities, decision points, and hazard actions in relation to time. The design of the matrix incorporates the ROS and associated functions on the left side (vertical axis); the disaster time line, decision points, and tasks associated with the ROS are portrayed at the top (horizontal axis). Figure 2 depicts the layout that Argonne developed for the ERSM.

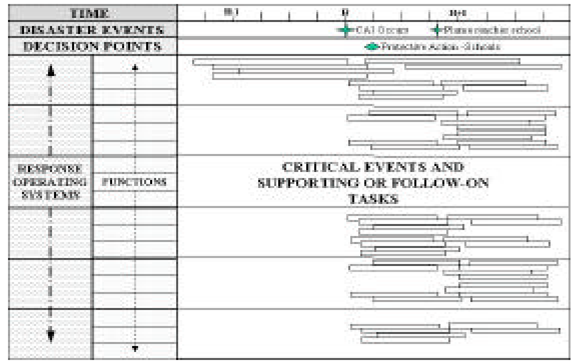

Figure 2. ERSM design

An ERSM for a specific site is constructed by performing five steps. The first step is to establish a prescribed time line or a set of predetermined phases of a response. Time entries are based on set intervals (i.e., hours/minutes or days/hours), while phases are defined as process intervals (i.e., preparedness, response, recovery, and mitigation). The second step is to record when significant disaster events would occur, such as the time at which a chemical plume tip reaches a discrete receptor. The third step involves entering decision points, that is when an emergency manager or coordinator must make a decision to have an optimal effect on the outcome. The fourth step is to indicate critical events, where an activity directly influences the responses and actions by triggering a sequence of single or multiple actions or essential tasks. The fifth step is to enter all of the supporting and follow-on response tasks and activities. Both critical events and supporting tasks and activities are entered into the ERSM in relationship to the ROS, disaster time line, and decision points. Figure 3 is an example of a response action flow.

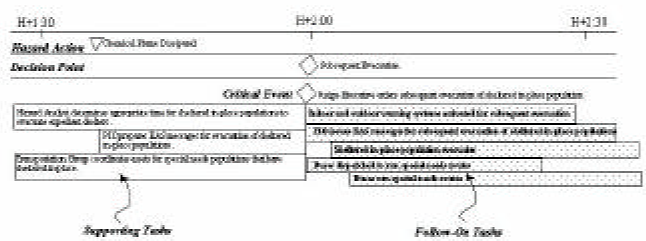

Figure 3. Sample response flow

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ERSM AND ITS USE IN THE EMERGENCY PLANNING CYCLE

ERSM can be used to improve emergency plans. Once individual jurisdictional matrices have been constructed, reviewed, and modified, then a rolled up matrix is produced for community review for the purpose of matching and modifying times and jurisdictional interactions. Lead planners then look for gaps and discrepancies among the individual and collective planned responses. From the rolled-up matrix, the general concept of operations is assessed as to whether it can achieve the end state desired with the resources available and with the level of protection wanted for the public. This emergency planning cycle can be repeated continuously and also can be initiated at any of the process steps shown in Figure 4.

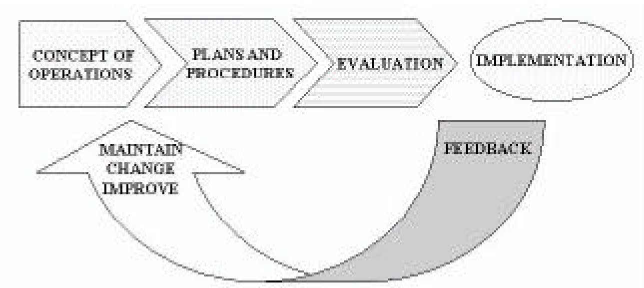

Figure 4. Process steps in the emergency planning cycle

The continuous emergency planning cycle is affected by a many external and internal factors. The concept of operations is reformulated based on frequent changes in local, state, federal, and organization policy, standards, equipment, personnel, and training, as well as hazard analyses and capability assessments. Plan, procedure, and checklist rewrites are the result of adjustments to the response visualization (desired end state, sequence of actions, and organized response area) caused by war-gaming and resource loading. Exercise and execution of plans, procedures, and checklists during training, hazard response, and table-top, partial, and full exercises, coupled with an integrated and synchronized emergency operations review, offer the opportunity for validation. An anticipation of future responses and assessments of the current status based on responders' insight and feedback, along with data analysis, after-action reviews, and exercise reports, affect the concept of operations.

SOFTWARE SUPPORT

An ERSM can be "built" with pen and paper, as the Army's combat synchronization matrices were originally produced. While adequate for producing and distributing matrices for plans that will be carried out within 24 to 72 hours, this method does not sufficiently support the typical emergency planning process, which is characterized by annual plan reviews and infrequent plan execution. Thus, Argonne has developed computer software to support the ERSM development process.

The general "look and feel" of the software follows current project management and database software design concepts wherever possible. This allows for leveraging the existing experience of emergency planners who currently use these applications. All the functionality of the system can be accessed through the main menu, which provides several options for data entry and chart display and report generation.

Software Description

File options contain tools to set up the data for the system. Jurisdiction files are set up for each county, city, state, or other affected area or organization for which a plan is being developed. Interactions between jurisdictions occur in actual emergencies, and the individual plans must be "rolled up" into a single plan for thorough testing of collateral effects. The roll-up option provides the capability to link activities from different jurisdiction data sets as predecessors in a combined matrix. This provides a powerful option for viewing a plan and displaying a combined chart that shows how jurisdictions would work together in an emergency situation as evidenced by their plans, procedures, and checklists or as determined through added adjustments resulting from interviews.

Activities are key events or tasks that must occur upon execution of an emergency plan. Activities provide information on components of the plan, procedures, or checklists of a specific jurisdiction, such as a description of the activity, its predecessor, resources required, supplemental data, guidance objective, and source reference. Each of these activities belongs to a particular function, which may belong to a particular operating system. Two types of activities are available in the system — planning activities available to all users and exercise activities restricted to "trusted" (exercise) users.

Each activity is logically grouped through an assigned function descriptor and the functions are then logically grouped or tiered within operating systems to ease understanding of relationships among various functions. Functions and operating systems can be customized. Data can be entered or edited through either a data entry grid or data entry form.

A host of system options exists, such as customizing the size and style of the activity boxes, performing spell check, selecting colors and fonts, choosing options for setting data displays of activity information, and printing.

The results of the matrix can be displayed as either a matrix chart or a series of standard reports. Charts display the data as "boxes" on the screen, arranged in a relative position in relation to the operating systems, functions, and activities. The general layout of the matrix and the text that appears in the boxes is configurable. Seven standard reports are available, including a valid activity report, invalid activity report, exercise activity report, critical activity report, function report, operating system report, and jurisdiction report. The difference between a valid and invalid activity is that valid activities have complete information in all the necessary fields for the matrix to perform the calculations needed to produce a chart.

System Requirements and Software Testing

The software is designed to run on a Pentium or Pentium equivalent computer with 64 MB of RAM manufactured in the past three years. It requires approximately 10 MB of disk space to install and execute and will run on Microsoft® Windows™ 95/98/00 or Windows™ NT® 4.0. The software comes with comprehensive online help that will assist with program operations.

The Synchronization Matrix Charting System© (SMCS) was initially tested in Utah with the Deseret Chemical Depot CSEPP community, which consists of five jurisdictions (a storage site, the state, and three counties). Follow-on developmental testing, validation, and verification of SMCS 1.0 took place in Colorado (a storage site, the state, and one county) and in Kentucky (a storage site, the state, and nine counties). SMCS 2.0, which provides additional features suggested by users during the previous implementations, is undergoing *beta* testing and will be used for developing an ERSM for the Pine Bluff Arsenal CSEPP community (a storage site, the state, ten counties, and two municipalities).

CONCLUSION

Emergency planning for potentially catastrophic natural or technological disasters cannot be done or implemented without the coordination, integration, and synchronization of the individual responses into a community response. Inter-jurisdictional interactions and consequences must be planned for and exercised. This theme is repeatedly found in the disaster response research of the past three decades. In 1980, Tierney [2] stated that “members of responding organizations must know not only what to do, but also what role their organization is seen as playing in the larger response.” In 1992, Lindell and Perry [8] stressed that “the success of disaster response operations is substantially affected by the achievement of effective inter-organizational coordination among responding groups and organizations.” In 1999, in describing a hypothetical Sarin disaster, Caro [9] lamented that the individual disaster plans of governmental departments were never coordinated and integrated with each other, nor tested as such.

The ERSM offers a proven, successful means to articulate, coordinate, integrate, and synchronize a community’s emergency response across time and space. It promotes the visualization of the response by graphically portraying the activities to be performed by participating jurisdictions and response organizations. It also provides a process where planners can ascertain a clear understanding and visualization of what is going to be involved in a response to a particular hazard. It looks at the current state of the responding jurisdiction (location in relation to the hazard, available equipment and personnel, equipment readiness, training levels, policy, standards, and guidance). It clearly discerns the desired end state — more than “protecting the public” — and a feasible outcome. It envisions a sequence of actions (general or various levels of specificity) that would cause the response to reach that targeted end state.

This tool, while developed for a specific accident type, has the capability to tie together all aspects of the emergency planning cycle and to capture the many dimensions of a complex response for any type and magnitude of potential natural and technological disaster currently facing a community. In this increasingly complex response environment, the multi-chaptered, several volume emergency operations plan, procedures, and checklists are not adequate. Emergency planners must employ a new paradigm, and it should draw heavily on the Army Air-Land Battle concept, which relies on the coordination, integration, and synchronization of military unit actions over a large geographic area for an extended period of time. The ERSM is an adaptation of this recently proven concept. It provides an all-hazards planning and exercising tool that allows any individual, jurisdiction, or organization responsible for planning, evaluating, or conducting an emergency response to do so in a coordinated, integrated, and synchronized manner.

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Biography

Paul L. Hewett, Jr., is an Emergency Systems Analyst at Argonne National Laboratory providing research and technical support to the Army's Chemical Stockpile Emergency Preparedness Program. He has over 20 years of experience in contingency, emergency, and operations planning and readiness assessment.

Jacques E. Mitrani, is manager of the Integrated Preparedness Section at Argonne National Laboratory and provides research and technical support to the Army's Chemical Stockpile Preparedness Program. He has over a decade of experience with the Radiological Emergency Preparedness Program and has been involved in research related to the Arms Control and Verification program.

William C. Metz, Ph.D., is manager of the Social Science Applications Section at Argonne National Laboratory and has his doctorate in the field of geography. He has researched and published extensively on a wide range of controversial siting issues, including nuclear reactor and high-level radioactive waste facility siting, chemical and nuclear reactor storage and disposal, and planning the reuse of Department of Energy sites. He has been involved with emergency planning and exercising at nuclear reactor and chemical weapons depots for over a decade.

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